An Augmented Reality Environment for Astronomy Learning in Elementary Grades: An Exploratory Study

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ABSTRACT
This paper describes an ongoing research comparing two 3D astronomical tangible models: an Augmented Reality model *versus* a physical model. According to IBSE principles, learners should investigate and manipulate in order to become conscious of the origin of astronomical phenomena, construct scientific knowledge and change their misconceptions. In primary French schools, physical models are usually used. However, children do not take advantage of these models and form new synthetic models instead of scientific ones. We aim at providing an adapted pedagogical environment support. An Augmented Reality environment was designed for inquiry-based learning. This tangible AR model shows augmented views of the celestial bodies and supports the pupils' investigations using spatial visual guides and views from a terrestrial observer. The AR model not only exposes the phenomena as in several Virtual Environments, but also allows pupils to virtually move the celestial bodies and test "as for real" their hypotheses. Our results show that the AR environment is particularly suitable for astronomy learning compared to the physical one. Only AR users have developed scientific conceptions of the explored astronomical phenomena and learnings have been significantly improved. Furthermore, we present some arguments in order to support the assumption that the AR model assists the process of scaffolding and motivation dynamic by enhancing task controllability and by promoting collaborative learning.

Author Keywords
Astronomy; Augmented Reality; Learning, Inquiry-based Sciences Education.

ACM Classification Keywords
H.5.1 Multimedia Information Systems

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INTRODUCTION
Today, astronomy has to be taught at primary, secondary and high school as part of the curriculum. But very few targeted teaching material is available for teachers and learners in France (resources are mainly textbooks and physical models). So, there is a real need to develop digital astronomical didactic materials.

The specific project of our study concerns the development of a tangible user interface for an Augmented Reality (AR) environment adapted to Inquiry-Based Sciences Education (IBSE) [18, 28]. The main goal of our project is to provide easy-to-use teaching/learning tools for learners and teachers in elementary grades, in accordance with the French curriculum in astronomy. We aim at providing an adapted pedagogical support to learners to help them acquire new concepts and overtake misconceptions about fundamental astronomical concepts described in the primary grades curriculum. The main contribution of this study is a comparison between two 3D tangible models, physical and virtual, proposing the same possibilities of manipulation. We also evaluate the impact of AR on the development of children's knowledge on a complex astronomical concept (moon phases).

CHILDREN'S KNOWLEDGE OF ASTRONOMY AND AUGMENTED REALITY ENVIRONMENT
Some concepts of astronomy have been taught at elementary school in France since 1985. More precisely, the program is focused on the solar system, earth motion, day/night cycle, seasonal changes, moon motion and moon phases. For fifteen years, a lot of studies have shown that children of various cultures have difficulties in understanding contemporary scientific explanations of elementary astronomic phenomena [6, 19, 20, 29, 39, 44, 45]. Astronomy is a field where the information collected by means of personal experience contradicts contemporary scientific theory [19].

From a cognitive point of view, children synthesize (construct) their knowledge of the world and the universe on the basis of two information sources: observations of the world and explanations given by other people [44]. In the continuity of Bachelard [4], Vosniadou and her colleagues [43-47] have determined three types of cognitive models, i.e., three steps in the construction of scientific mental models of the world and the universe:

1. Initial model: the initial model is based on children's everyday experiences (e.g., seeing the flat surface of the earth) and on the entrenched beliefs derived from those early experiences;
2. Synthetic model: children form synthetic models after they are exposed to the contemporary scientific information. These are formed as a result of attempts to reconcile their presuppositions with the information they receive from adults;
3. Scientific model: since adolescence, the majority of Western people have accepted as truth the scientific views.

Children learn informally about the physical and astronomical phenomena in daily life long before official instruction are provided at schools. This can be a source of problems, especially when children's preliminary knowledge radically differs from what is taught in school. If these knowledge are integrated and consistently used, children tend to reinterpret the new information in accordance with their preliminary models and to form new synthetic models instead of scientific ones [19, 20, 47]. As recommended by European and French institutions [14, 16] and to make science learning more efficient [12, 13, 18, 28], especially in astronomy [40, 47] the following inquiry-based pedagogical principles [35] must be proposed: (1) explicitly talking about children's preliminary knowledge and exploring different ideas to make them become conscious of their understanding/expertise; (2) showing the inconsistencies between everyday and scientific explanations and their reasons; (3) making children become conscious of their entrenched beliefs in order to change them; (4) giving the new explanations verbally and allowing pupils time to consolidate their thinking; (5) facilitating debates and leaving enough time for discussions.

We argue that AR environments are particularly suitable for astronomy learning according to IBSE precepts. AR is one of the most promising technologies in education for about ten years [26]. However, implementations in primary school are uncommon (e.g. [7, 8, 23, 25]). Existing works mainly focus on applications in university education (architecture, biochemistry, mathematics, anatomy or physiology…) (e.g.[9, 10, 22, 49]). To our knowledge, only one study concerns astronomy [36]. However, one of the most promising development axes probably emanate from the scholar public. Moreover, the educational subjects that mobilize the appropriation of abstract concepts and spatial representations are very frequent in primary school programs, and all those subjects could be supported by AR.

Some prototypes of Virtual Reality (VR) environments have been proposed to teach/learn astronomy (e.g.,[5, 17]) but these are too complex for elementary learners, or too expensive for French teachers, or not adapted to the French curriculum in astronomy for elementary levels. Moreover, they do not open the possibility for real manipulations. The AR tools seem to be the best environments as feedback provider and simulator for numerous teachers [34]. In comparison to VR, which aims at immersing the user in a synthetic environment, AR is a technology that allows computer-generated virtual imagery information to be overlaid onto a live direct or indirect real-world environment in real time [3, 24, 38]. In other words, in AR environments both virtual and real objects can co-exist and interact in real time. The user experiences are more realistic and complex spatial relationship can be easily visualized [1].

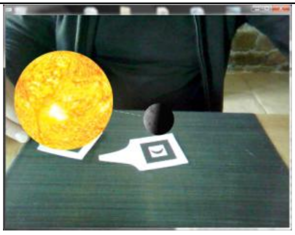
In order to get a correct alignment between the virtual scene and the real scene, the pose of the observer (or camera) with respect to the scene has to be known at all times. A widely-used method to get the pose in real-time consists in using artificial markers that can be rapidly and efficiently detected and identified in a video flow. Several implementations are available to perform detection, we use Artoolkit [21] in our experiments. The term "tangible interface" is used to designate interfaces that allow manual manipulations of the markers, where each marker is associated with a 3D object or a particular action. This kind of interface provides "sensorimotor feedback" [37]. Direct manipulations can supplement the deficiency of mouse-based computer-generated visualisation, since mouse manipulation is an indirect physical manipulation [9, 37]. According to Shelton and Hedley [36], AR interfaces do not change the delivery of instruction content but change the way that content is understood, through a unique combination of visual and sensory information.

PRESENTATION OF THE AR LEARNING ENVIRONMENT

A virtual learning environment has been designed to enhance the conceptualization of earth and moon shadows' origin, the length of the day and the night on the earth and on the moon, and finally the evolution of moon phases. The AR model does not just expose the phenomena as in several virtual environments (e.g.[5, 17]). Here, the virtual celestial objects can be moved to make "as for real". In our AR environments, virtual sun, earth and moon are associated to specific patterns. Therefore each marker is easily identifiable. Visual guides are provided to help the user understand the three celestial bodies' relationship. Sun, earth and moon appear realistic as they are represented using textured 3D spheres (textures were obtained from space images).

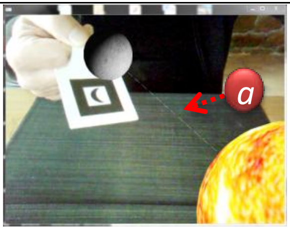
The light properties were taken into account and self shadows of earth and moon were directly produced by an omnidirectional light source associated to the sun. Different visual guides are proposed to support learners (see Figure 1). In particular, an optional vignette can be displayed to see the subjective view of a virtual terrestrial observer in real-time.

1- The moon marker is put in front of the camera ; as the sun marker has not been introduced yet, the virtual moon is completely black.

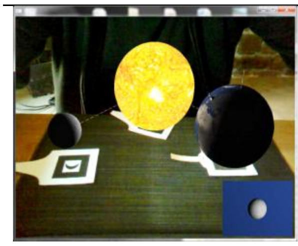


2 - The sun marker is introduced and the virtual moon is illuminated by it. The sun marker is moved, changing the appearance of the moon as observed “from space” (camera view).

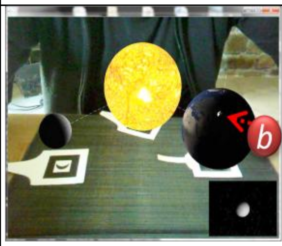
3- The sun marker is removed but the virtual sun is still displayed; as long as the sun marker is hidden, the last measured position of the sun relative to the moon is used to display the sun.



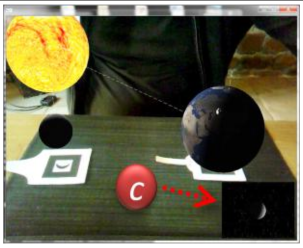
4- The moon marker is moved in order to observe the moon from different viewpoints. As the position of the sun relative to the moon is fixed, the moon illumination is not changed during this operation.



5- All markers (moon, sun and earth) are put on the table. A virtual observer is drawn on the surface of the earth (in France by default); a vignette is displayed bottom right of the screen, showing the moon’s appearance for the terrestrial observer.



6-The terrestrial observer has been moved toward the east along a geodesic path, using a keyboard key; the moon’s appearance has changed in the vignette; moreover, as the terrestrial observer is now on the dark side of the earth, a night sky is displayed in the vignette.



7 -The sun marker is moved, changing the appearances of the celestial bodies, both for the spatial and the terrestrial views

Figure 1 : An example use of the AR learning environment. First person perspective. Visual guides proposed to support learners :(*a*) dashed-lines between bodies’ centres (*b*) a terrestrial observer (*c*) vignette showing the terrestrial observer’s view in real-time (optionally proposed).

Therefore, this AR environment provides users with experiences they would otherwise not be able to experience in the physical world.

Moreover, it is possible to adjust the difficulty level according to education objectives, to adapt the level of freedom to move markers. Then, this AR model can be used in inquiry-based education. It is certainly the first Augmented Reality astronomical model adapted to primary students, IBSE and French institutional curriculum. Traditionally, the teachers of French primary classes use classical physical models which possess a large part of these parameters (i.e. manipulation possibilities, physical representation of celestial bodies, investigation possibilities...) crucial for astronomy learning [28, 30, 33, 35].

The aim of this study is to assess whether this AR environment improves inquiry-based learning compared to a physical model.

METHOD

With an exploratory experiment conducted with 39 young French learners from primary classes, we investigated the potential of this AR environment to improve learning in astronomy by comparison with a “traditional” physical model.

Participants

All the learners were recruited from Grades 4 and 5 in one French school. Students are from 8 to 11 years old and 59% of them are male. The pre-assessment on moon phases’ origins pre-conceptions has allowed subdividing the participants in two similar panels (p-value= 0.8269 using Fisher's Exact Test) also taking into account the age and gender of pupils (see Table 1). The pupils’ experiences on both models have been included in an inquiry-based pedagogical sequence, consisting of 6 steps synthesized in Table 2.

Pupils were separately assigned to panels at the fourth and fifth steps of the pedagogical sequence. The first panel -panel A- (see Table 1) had access to the AR model to resolve astronomical problems (see Figure 1) whereas the second panel -panel B- had access to a classical physical model to resolve exactly the same problems (see Figure 3). This physical model was constructed and implemented as described in some manuals commonly used by French teachers (e.g.[2, 15]). Both panels used the same inquiry-oriented pedagogical sequence during the other steps.

Setting and procedure

As exposed by Campos, Pessanha and Jorge [7], the impact of technology cannot be fully understood without considering the global educational context. The study took place during 6 non-consecutive days, in respect with parental and institutional agreements.

PANEL		A	B
n		20	19
Male nbr (%)		12 (60%)	11 (58%)
Age Mean (SD)		9,65 (1,03)	9 ,31 (1,15)
French Grade	*CE2*	7	7
	CM1	4	3
	CM2	9	9
Pre-assessment results	*Acquired*	3	4
	Underway	6	4
	Not Acquired	11	11

Table 1: Subdivision of the 39 pupils in the two panels. CM2 corresponding to 10/11 years old students, CM1 to 9/10 years old students and CE2 to 8/9 years old students.

The research team conducted all steps of the pedagogical sequence. So, a combination of pre and post-tests, analyses of pupils' workbooks, digital logs of the markers for the AR model, observations and videotaping, could develop a better understanding of the influence of these environments on learnings.

Steps 2 and 3 aimed at assessing and talking about the children's preliminary knowledge about origin of moon phases observed during the previous month (step 1). The discovery time, due to the AR "magical effect", may limit the interest in learning as in the Kerawalla, Luckin, Seljeflot and Woolard [23] study. Other AR environments were presented during step 3 to the children of panel A. They could play, test marker mobility, understand the feedback nature and then adapt to this type of augmented environment.

During steps 4 and 5, the AR system was set up in computer rooms to perform the exercises and students were videotaped in action. A Logitech QuickCam pro 9000 video camera was connected to a laptop computer Centrino2 running Windows Vista. Simultaneously, the classical physical model was set up in another small room of the school, where the overhead lights could be switched off to darken the room during the whole experimentation (see Figure 2). In both conditions ("AR environment" vs. "Physical model") pupils were asked to cast doubt on their conceptions. Students of panel A filtered through the AR model over a day at step 4 and with the same methods one week later for the step 5.

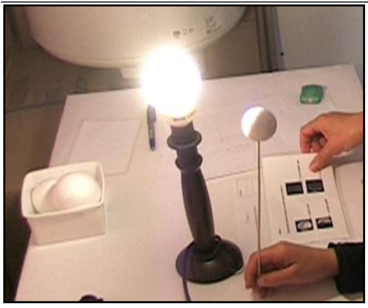
Simultaneously, panel B filtered through the classical physic model. Both had to investigate on the origin of moon phases based on similar problems.

Step	Delivery type description	Pedagogical Objective
1	Contextualization of learnings : individual observations of moon phases for four weeks	Have a personal observation of the evolution of moon phases
2	Diagnostic assessment of conception about moon and moon phases (the same for all students) and collective discussion based on personal observations and on various astronomical phenomena	Situate his/her observations in the didactical context and verbalize his/her conception of the phenomena.
3	Problem statement: Discussion with student about moon and astronomical phenomena. *Discovery of different AR environments by students of panel A*	Discuss his/her conceptions to make them conscious and formulate hypotheses.
4	Problem-based student investigations on moon and earth shadows' origin; by pairs, using an astronomical model *(AR or PM)* and supervised if necessary. First learning review	Understand, after investigations, the shapes of moon view from earth.
5	Problem-based student investigations on the evolution of moon phases; by pairs, using an astronomical model *(AR or PM)* and supervised if necessary. Second learning review	Understand, after investigations, the physical origin of the evolution of moon phases
6	Summative evaluation (the same for all students)	Reinvest learnings and evaluate acquisitions

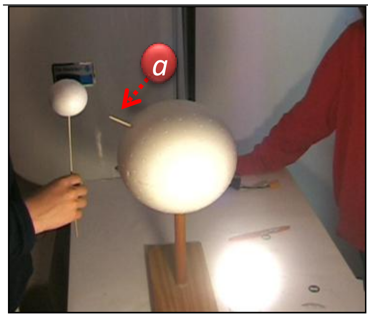
Table 2: Pedagogical sequence, similar for both panels (except for parts in italics), including time for investigations (steps 4 and 5) using either models types (AR or physical models).

First, they had to find the principal moon phases viewed from earth (new and full moons, crescents, gibbous and quarters) and testing their conceptions on the moon shape evolution observed during the previous month (e.g. moon has white and black hemispheres, the dark zone on moon is due to earth's shadow or clouds, the evolution of the way we see the own shadow of moon during the lunar revolution). These experiments lasted 45' on average for each, working by pairs for both panels. Students had their experiment workbooks to note their hypotheses and results.

Secondary, they had to be able to replace the moon in the sun/earth/moon system viewed from space during 4 moon phases (new and full moons, waxing crescent, last quarter) by testing their conceptions.



1- A small ball (moon) is placed against the light (sun). It is moved around the lamp in order to observe the moon from different viewpoints. This is then a modelling of the shadow production on moon and of the apparent moon phases observed from earth (as in picture 2, 3 and 4- Figure 1)



2- The moon-ball and another big one (earth) are placed against the light. The moon ball is moved around the earth ball in order to observe the moon shapes evolutions. It is a modelling of the lunar month view from space (as in pictures 5, 6 and 7 – Figure 1).

Figure 2 : An example use of the physical model traditionally used in primary school. (*a*) Symbolic representation of a terrestrial observer.

Both experiments for the two panels were videotaped. The marker motions were stored during each working session to provide statistical data. During step 6, the knowledge of pupils on astronomical concepts were once again assessed and each of them was asked to put on paper the astronomical concepts constructed during this sequence.

RESULTS AND DISCUSSION

In this paper, data analysis is mainly focused on pre- and post-assessments. These assessments are associated to verbal exchanges noted during steps 2&6 and to analyses on pupil workbooks. Both correspond to question series about moon's phases (names, shape, origins, and physical explanation) constructed after Hannust and Kikas [19], Straatemeier, van der Maas and Jansen [39], Thouin [41], and an exercise from a classical school manual [2]. From 4 different earth/moon/sun locations, seen from above, looking down on the Earth's North Pole, students had to draw the 4 different moon phases as viewed by a terrestrial observer. Both assessments verified the skills "Explain the moon shape origin and the evolution of moon phases" and "Recognise and represent exactly the apparent moon phases for a terrestrial observer from spatial Earth/Moon/Sun representations".

As reported by Hannust and Kikas [20], for any learning, children need new terms, facts and explanations. Then, further knowledge had to be introduced in order to explain the phenomena.

The pre-assessment and post-assessment were analysed predominantly using 3 criteria, indicators of student learning: (1) type of vocabulary (scientific or not) used both verbally and in writing form; (2) drawing task quality (e.g. construct using observation, using didactical routine...); (3) explanations and arguments provided to open-ended questions.

The pre-assessment worksheets were collected during step 2. Results (see Figure 3 and Table 3) indicate that the majority (56%) of students explain lunar month using naive mental models (e.g. "moon has white and black hemispheres", "dark sector on moon is due to projected earth shadow") or entrenched beliefs (e.g "the moon is not entirely visible because of clouds between earth and moon", "it is due to the shadow of another planet"). Only 7 of the 39 students had a scientific model to explain and no difficulties to draw moon phases during the exercises. These results then confirmed the numerous recent studies on this subject [19, 20, 29, 31, 39]. The post-assessment were collected during step 6, one week after the last investigations on models, and after the 5 steps of learning.

For the two different panels, learning significantly increased (p-value = 0.008 for panel A and p-value = 0.020 for panel B, using Fisher's exact test). Most of the pupils make sufficient progress in learning to succeed, in whole or in part, the post-test (see Figure 3 and Table 3: "Acquired" and "Underway").

For both panels, we did not identify remaining entrenched beliefs and only 5 students continued to explain lunar month using naive mental models, and had many difficulties to draw moon phases ("Not acquired"). Synthetic models were mostly expressed (e.g. "it depended on how we saw the dark part of the moon")

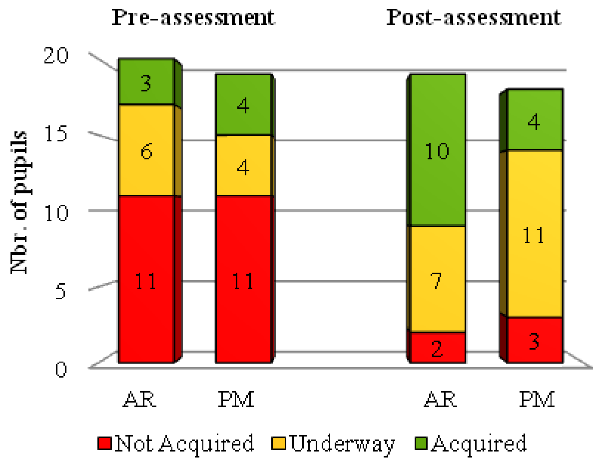


Figure 3: Assessment results summarized in acquisition levels.

	Draw moon phases and explain technique used	Acquired		Underway		Not Acquired	Conception of origin of moon phases		
		Draw correctly the moon phases. Give a scientific technical explanation	Draw correctly the moon phases. Give a methodological technical explanation	Drawing mistakes remain	Spatialisation and drawing mistakes remain	Everything is incorrect	Scientific	Synthetic	Naive
Pre-assessment	CM2	-	2	-	3	4	2	4	3
	CM1	-	1	1	1	1	1	1	2
	CE2	-	-	-	1	6	-	5	2
	panel A	**0 (0%)**	**3 (15%)**	**1 (5%)**	**5 (25%)**	**11 (55%)**	**3 (15%)**	**10 (50%)**	**7 (35%)**
	CM2	1	2	1	1	4	3	4	3
	CM1	-	1	-	1	1	1	2	0
	CE2	-	-	-	1	6	-	4	3
	panel B	**1 (5%)**	**3 (16%)**	**1 (5%)**	**3 (16%)**	**11 (58%)**	**4 (20%)**	**10 (50%)**	**6 (30%)**
Post-assessment	CM2	2	3	-	4	-	5	3	1
	CM1	-	1	1	-	1	1	1	1
	CE2	-	4	2	-	1	3	4	-
	panel A	**2 (11%)**	**8 (42%)**	**3 (16%)**	**4 (21%)**	**2 (11%)**	**9 (45%)**	**8 (40%)**	**2 (10%)**
	CM2	1	2	3	2	1	3	4	1
	CM1	-	1		2	-	1	2	-
	CE2	-	-	3	1	2	1	4	2
	panel B	**1 (6%)**	**3 (17%)**	**6 (35%)**	**5 (28%)**	**3 (17%)**	**5 (26%)**	**10 (53%)**	**3 (16%)**

Table 3: Pre- and Post-assessments distributions of the study participants according to their panel (absolute and relative values - Panel A using AR model and panel B using PM model) and acquisition criteria or conception types. Variables are detailed for each French grade and each panel.

However, and even if students were in the same pedagogical conditions (see Table 2), the number of pupils who present the astronomical skills required ("Acquired") significantly improved when students investigated the AR model (p-value = 0.019 using Fisher's exact test) compared to the physical one (p-value = 0.935 using Fisher's exact test). Moreover, their scientific expression is more pronounced (45% of the panel A compared with 26% of the panel B) and even for the younger pupils (CE2 - 8/9 years old).

These results confirm that when using physical models, users do not much benefit from manipulations to change their conceptions [27, 33].

Secondly, we used pedagogical observations and videotaping to identify the factors that might influence improvements and if it has an impact on specific learning outcomes.

During step 4, students of panel A were more motivated and eager to go on. This was due to the attractiveness of the AR model. These behaviours were limited in panel B. Nevertheless, this eagerness rapidly decreased. Thus, free manipulations observed during the first part of step 4-investigation were not observed during the second part and during step 5. For these young pupils, currently exposed to new technologies, and after this appropriation time, it is not the attractiveness of new technology that motivates users but really the scientific question and its challenge goal. Therefore, this study based on a learning sequence (and not only on one working session) indicates the importance of taking into account this appropriation time before inferring on influences due to a new virtual environment on user interactions, learning or motivation.

In both modelling contexts (steps 4 and 5) the duration of student activities were mainly the same (35'), all started quickly their investigations and did not hesitate to request teacher (about 6 to 7 times per inquiry-based sessions). All pairs of each panel, in exception of GR14-Panel A and GR7-Panel B, succeeded in resolving the astronomical problems after testing their various hypotheses and discussing together their protocols and results. Both models improved student investigation and were adapted to the age of the learners (8 to 11 years old).

However, videotaping qualitative analyses indicate two major differences between the two panels which could influence learning improvements associated to the AR model:

1- Tool for scaffolding [48]. Every physical model users has shown up many handling difficulties, particularly to move balls, to decide to turn around the table, to orient the devices etc. But all these movements were yet necessary to construct a correct spatial understanding with this type of models. Combined abstract thinking, cognitive and motor efforts for spatial situation involve here too much solicitations. For the AR model, users encountered problems with intermittent images when their hand or fingers occluded parts of the marker, and had some difficulties in understanding the marker positions and orientations in the webcam view.

Most of the students of panel B (except the GR5-Panel B pair) indicated recurrent visual difficulties during their manipulations. For example, to recognize the moon position between earth and sun and be able to explain a waxing crescent, viewed by a terrestrial observer, students had to orient their eyes as if they were the terrestrial observer and had to decentre themselves. Inversely, the users of the AR model systematically used the vignette to verify their hypotheses. As expected, real-time view of the terrestrial observer facilitated and supported users' investigations. The realism and the simple mobility of the virtual celestial objects were strongly promoted. Moreover, by simply manipulating markers, students were able to easily view and interact with complex phenomena. Also, the virtual model provides the necessary visual and tactile information needed to understand the optical phenomena at the origin of moon phases and then develop their conceptions. In other words, the AR model is an important tool for scaffolding pupils on this particular point.

2- Dynamic of motivation support [42]. The step 5 of the panel B, students frequently dropped out their investigations (more than twice more than in panel A groups). As we have seen above, the AR environment enhances usability and plays an important role in scaffolding learning. Then, the AR model allowed users to concentrate on their tasks and then enhanced task controllability. Moreover, in both models, students worked together but not with the same behaviour. Dillenbourg, Baker, Blaye and O'Malley [11], or Panitz [32], indicate that collaboration involves joint intention, mutual and coordinate effort, whereas cooperation involves greater labour division.

In panel B, using the physical model, students systematically divided up tasks and proceeded in interaction. For example, a student gave movement indications to a second one, his assistant – e.g."Put the moon here... Wait! I look", "turn around"-. They were complementary but organized in separate tasks. In other words they have cooperated. This is certainly due to the number of tasks, movements and cognitive efforts exposed previously. Dissensions were frequent in these groups and in most cases, one directed the investigations and moreover, only one is in good position for observations. In panel A, they frequently exchanged their points of view and ideas, worked together towards the same purpose (e.g. one moved moon markers or terrestrial observer and the second provided screen control) and manipulated the system alternatively. Two-thirds of panel A-groups assisted each-other. These collaborative work, based on mutual aid and associated work, was preferred by students.

The AR model seems to facilitate collaborative learning interactions between students. The AR model enhances social context and environment, which are important parts of student motivation and self-regulation.

CONCLUSIONS AND FUTURE WORK

This study, based on an inquiry-based learning sequence, and not only on one working session, indicates the importance of taking into account the need for appropriation time before inferring the influence of a new virtual support. It shows the relevance of an AR model compared to a physical one to provide a learning environment easy to use for students in grades 4 and 5 and adapted to IBSE. This augmented learning environment enhances significantly astronomical learning. Further assessment analyses, qualitative analyses of combined data of videotaping, pupils' workbooks and observations improve our comprehension of the AR environment rule on learning. Because the AR model enhances sensory motor interactions, visual guides and realistic representations, pupils benefit from a reduced complexity to construct a scientific comprehension of phenomena. Therefore, AR model assists the process of scaffolding. Then, this AR learning environment contributes to make the misconceptions became conscious in order to construct scientific mental models. Moreover, cognitive support and handling ability, improve their capacity in resolving astronomical problems. The AR model then allowed users to concentrate on their tasks and then enhanced task controllability. By promoting collaborative learning interactions rather than cooperative ones, the AR model takes part of the dynamic motivational process.

The next phase of this research will take spatial procedures into specific account, through statistical data of marker motions, used during investigations with the AR model. Related to the assessments and combined data, we aim at providing arguments to characterize the procedures used by children to overtake their conceptions. Increasing the participant number would improve our inferences and would enhance comprehension on inquiry-based learning strategies.

Additionally, this experiment will be duplicated on pre-service teacher students. As children, currently teachers (i.e., adults) have principally non-scientific conceptions about the astronomical notions they will have to teach. We aim at characterizing if adults overtake misconceptions as do children.

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